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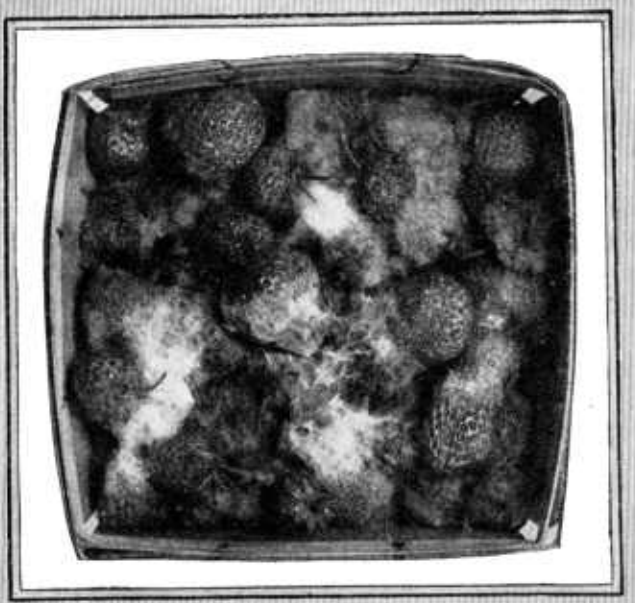
STRAWBERRY DISEASES



THE GREAT VARIETY of conditions under which the strawberry is grown necessitates different methods of culture and handling. Methods of control of strawberry diseases must be adapted to local conditions.

Severe attacks of leaf diseases—leaf spot, scorch, and mildew—may be controlled by spraying or dusting. Usually, however, these diseases may be held in check by frequent renewal of strawberry patches. Except in the Gulf States, the losses from these diseases are usually not regular or severe enough to justify the expense of spraying.

The only practicable method of control of diseases caused by nematodes is crop rotation combined with the planting of healthy nursery stock.

Although the virus diseases are carried by insects, no method is now known by which the insects may be so completely controlled as to prevent the spread of these diseases. Until such time as resistant varieties can be developed or other methods of insect control devised, the grower will be forced to depend on the removal of diseased plants and the planting of healthy stock for the control of virus diseases.

Field rots may often be reduced by proper mulching. Careful handling and adequate refrigeration will greatly lessen the losses from rots which occur after picking.

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STRAWBERRY DISEASES

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INTRODUCTION

STRAWBERRIES are more widely grown in the United States than any other small fruit. Not only is the strawberry particularly adapted to the home garden and found to some extent in such gardens in every State, but centers of commercial production are located in many widely different regions throughout the country. From these large centers of production fresh fruit is distributed over a period of more than six months each year. The growth of this fruit in so many different regions under widely different conditions has resulted in the development of special cultural methods particularly adapted to local requirements, and the locations of the growing centers with reference to the markets served have given rise to somewhat different handling and shipping practices.

The number of varieties of strawberries grown in this country is large. Although about 50 varieties may be considered of commercial importance, experimental testing plots often contain several hundred. New varieties are grown from seed with ease, and plants of several new varieties are offered to the trade each season.

In view of the extent of strawberry culture in this country, the different conditions under which the crop is grown, and the number of varieties cultivated, it is obvious that strawberry diseases will vary in importance in different sections. Consequently, few general statements as to the severity of a given disease or the resistance to disease of strawberry varieties can be made with the expectation that they will be everywhere equally applicable. Methods of control must also be adapted to local conditions. What is undertaken in this bulletin is to describe the more important strawberry diseases and to give an account of such control methods as are of proved value.

LEAF DISEASES CAUSED BY FUNGI

The diseases here grouped under the general term "leaf diseases" will sometimes be found to affect other parts of the plant. Leaf spot and scorch often occur on fruitstalks and mildew on the young fruit. They are most common and conspicuous, however, on the leaves.

LEAF SPOT

One of the most widely distributed and best-known diseases of strawberries, leaf spot,[1] as its name indicates, is usually confined to the leaves. When the spots caused by the disease first appear they are of a reddish or purplish tint, but as they increase in size the

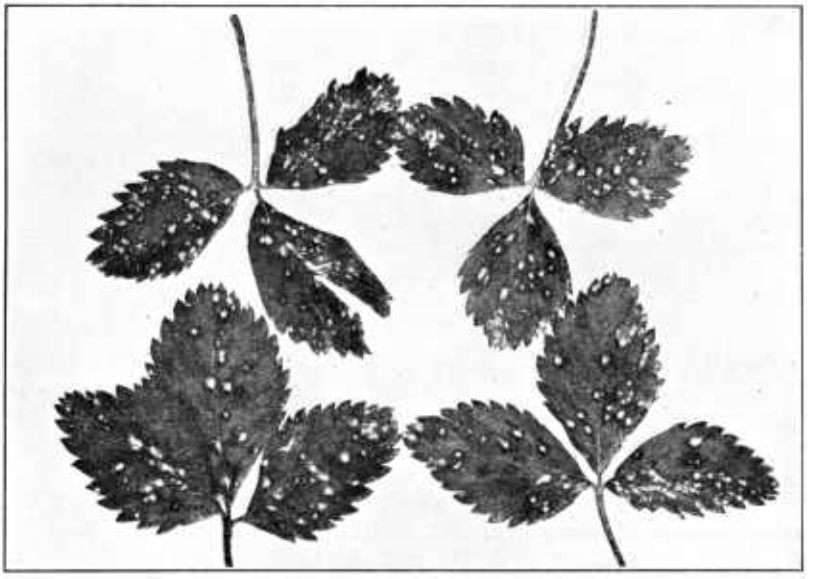

FIGURE 1.—Strawberry leaf spot. (Photographed by Wolf.)

center of each becomes paler and finally gray or almost white. A typical fully developed spot is about an eighth of an inch in diameter and has a dead white center surrounded by a distinct reddish or purplish border, which finally merges into the color of the healthy leaf. (Fig. 1.) The spots are scattered irregularly over the surface of the leaf and often become so numerous as to cause the death of a large portion of the leaf and in extreme cases even of the plant. Usually, however, the injury due to this disease is chiefly that of weakening the plant and reducing the crop through the loss of needed leaf surface.

SCORCH

Scorch[2] is almost as common on strawberries in this country as leaf spot, for which disease it may be mistaken in the early stages, when the spots or blotches, usually purplish in color, are irregular in

[1] Caused by *Mycosphaerella fragariae* (Tul.) Lindau.
[2] Caused by *Mollisia earliana* (E. and E.) Sacc. (*Diplocarpon earliana* (E. and E.) Wolf).

outline and vary in diameter from one-twentieth to one-fifth of an inch. (Fig. 2.)

The diseased areas gradually enlarge, and many of them grow together. In severe cases the whole leaf may become purplish or reddish in color. Soon, however, the leaf margins become dry (fig. 3) and have the burned or scorched appearance which has given rise to the name of the disease.

In case of severe infection entire plants may be killed or so weakened as to be worthless. One type of injury caused by this disease that results in large losses is the infection which often occurs on the fruitstalks, sometimes girdling them and thus causing the death of the flowers and young fruit.

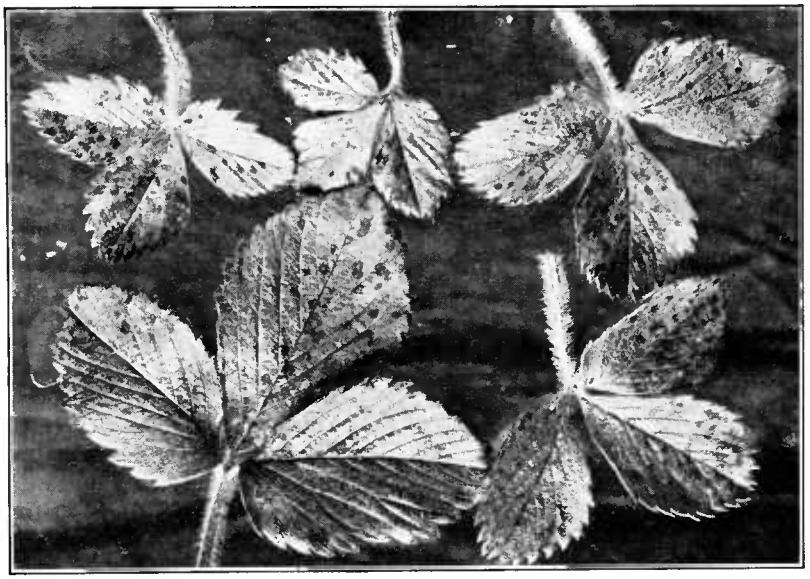

FIGURE 2.—The "spot" stage of strawberry scorch.

CONTROL OF LEAF SPOT AND SCORCH

That leaf spot can be controlled by spraying with Bordeaux mixture has been known for many years. Experiments by the Connecticut and North Carolina Agricultural Experiment Stations have demonstrated that scorch may also be controlled by this method.

It has been found most satisfactory for the control of leaf spot and scorch to spray with 4–4–50 Bordeaux mixture as soon as growth is well started in the spring—that is, when the first leaves are about half grown—and to repeat the treatment as often as may be necessary to keep the foliage well covered until the first berries are about one-third grown. It may be necessary to spray as often as every 10 days. Usually one or two additional applications in the late summer or fall will result in much better control.

Whether spraying should be undertaken in any particular case must be decided by the individual grower, taking into consideration its cost and the probable extent of the loss from these diseases. Often it proves more economical merely to reduce the diseases so far

as is practicable by frequent renewal of strawberry patches and by reducing the chances for infection. Mowing off and burning old leaves and removing diseased leaves before plants are set tend to reduce infection from strawberry scorch and leaf spot.

It is wise also to avoid setting any varieties that appear particularly susceptible to these diseases in a given locality. Lists of strawberry varieties that have proved very susceptible or resistant to certain diseases have been published at various times. These come from different workers and are frequently contradictory, the fact being, of course, that a variety may be obviously susceptible in one place or in one season and almost free from disease in another place or during another year. Reliable information as to the relative sus-

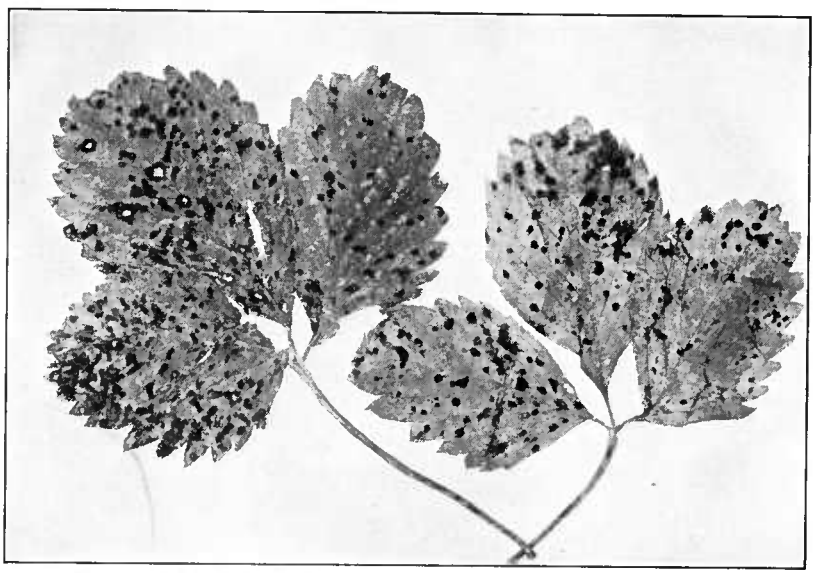

FIGURE 3.—A more advanced stage of strawberry scorch. The leaves are beginning to dry about the margins. (Photographed by Wolf.)

ceptibility of different varieties to various diseases is very difficult to obtain, owing to the fact that in large strawberry-growing sections one or two varieties are likely to be grown to the exclusion of others, and experimental plots usually contain relatively few plants of any given variety and are often maintained for only a few years. In order to secure reliable information on this point it would be necessary to carry on extensive comparative tests of the leading varieties in various sections of the country for a period of at least five or six years. The wisest policy for the present will be for each grower to select varieties on the basis of local experience in the region.

LEAF BLIGHT

Another disease which causes injury to strawberry leaves and leafstalks and has been found to be serious in Illinois and Michigan is angular spot, sometimes called blight.[3] The dead areas caused by

[3] Caused by *Dendrophoma obscurans* (E. and E.) H. W. And.

this disease even in the early stages are much larger than those made by leaf spot. Usually there is only one injured region to a leaflet, although there may be three or four. In an advanced stage this disease is distinguished by the more or less triangular shape of the dead area, which often extends from one of the larger veins to the side of the leaflet and includes all the leaf tissue between the edge of the leaflet and the vein.

MILDEW

Mildew [4] has long been recognized as a serious disease in England and is locally destructive in the United States. The most conspicuous symptom of the disease is the curling of the leaves. The edges of the leaflets gradually turn upward until much of the under side is exposed. If the under side of a diseased leaf is closely examined it will be found to be covered with a whitish down composed of the causal fungus.

For the commercial control of strawberry mildew in this country the ordinary sanitary measures recommended for leaf spot and scorch have usually proved sufficient. However, the New York (Geneva) Agricultural Experiment Station has demonstrated in the Hudson Valley that mildew may be practically eliminated even during seasons of severe infection by four applications of 85–15 lime-copper sulphate dust. The first application was made as the first buds were expanding in the cluster and the succeeding ones at intervals of about 12 days.

DISEASES CAUSED BY NEMATODES

Three distinct diseases of strawberries, namely, root knot, gall, and dwarf, are caused by nematodes. These are wormlike animals, and the species that affect strawberries are very small—from one-fiftieth to one twenty-fifth of an inch in length. The nematode gall of strawberries has been found only in the Northwest. Root knot, on the other hand, is found to some extent in all except the more northern States, but is usually serious on strawberries only in the Southern States. Dwarf is common in the Southeastern States.

NEMATODE GALL

The disease of strawberries known as gall [5] was first found in the United States in Oregon and is known only in the northwestern part of the country. The disease appears to affect only those portions of the plant which are above the ground. The plants as a whole are usually somewhat dwarfed and their color is of a lighter green than that of normal plants. As shown in Figure 4, affected leaves become wrinkled, swollen, and often much reduced in size. On the leaf and fruit stems are often formed conspicuous galls which contain the nematodes in great numbers. The nematode which causes gall on strawberries is known to occur in the United States on hyacinth, red clover, alfalfa, false dandelion, and the wild strawberry (*Fragaria chiloensis*) of the Pacific coast. It has been proved by inoculation experiments that nematodes from strawberries will affect red-clover seedlings. This suggests the possibility that

[4] Caused by *Sphaerotheca humuli* (DC.) Burr.
[5] Caused by the nematode *Tylenchus dipsaci* (Kühn) Bastian.

the pest passes from one host to another in nature and that it may be dangerous to plant strawberries in fields in which affected crops of red clover or alfalfa have been grown. For the present, however, the most necessary control measure is the obvious one of not planting strawberries that are infected or that come from infested fields.

ROOT KNOT

As indicated by its name, the disease known as "root knot"[6] is characterized by swellings or enlargements of the roots. Usually root knot produces no malformations on those parts of the plant which are above ground, and as a result it is frequently overlooked. If the roots of an infected plant are examined, however, the disease is usually readily detected. In severe cases great numbers of the finer roots and many of the large roots are found to be much enlarged at various points. These swellings, which are caused by the nematodes within the roots, vary greatly in size and shape.

The extent of injury to strawberries due to root knot is very difficult to estimate. Relatively few strawberry fields in the older growing regions of the South are free from root knot, and the reduced yield due to the disease has come to be taken as a matter of course. Often, however, the disease becomes serious enough to cause the death of part of the plants and can no longer escape notice.

When available, new land or land known to be free from the root-knot nematode should be used for strawberries. Infested fields, however, may be largely freed of infestation by a 3-year rotation with crops which are immune to this nematode.

The following plants are known to be immune or only slightly susceptible to root knot:

Barley.
Beggarweed.
Broomcorn millet.
Chufa.
Corn.
Cowpea (Brabham, Iron, Monetta, and Victor varieties).
Grasses (nearly all).
Kafir.
Milo.
Natal grass.
Peanut.
Pearl millet.
Redtop.
Rye.
Sorghum.
Soybean (Laredo variety).
Timothy.
Velvetbean.
Wheat.
Winter oats.

DWARF

The most conspicuous disease of strawberry plants in the southeastern part of the United States during the summer months is the one here referred to as dwarf, by which name it is generally known to growers in North Carolina, Louisiana, and elsewhere. In Florida, where the disease has long been known, it has received various names, including crimps, French bud, white bud, and brier bud.

The most conspicuous symptom of the disease and the one from which all its common names are derived is the malformation it induces in the young leaves as they develop. The leaves of diseased plants become greatly reduced in size and much deformed. (Fig. 5.) The edges of the leaflets are crinkled. In extreme cases the entire plant is dwarfed and the internodes of the runners are shortened. The disease is common throughout the southeastern part of the United

[6] Caused by the nematode *Caconema radicicola* (Greef) Cobb. A full description of the root-knot nematode, its characteristics on various hosts, and the known methods of control are given in Farmers' Bulletin 1345.

States from Virginia to Louisiana, in which region the symptoms are most conspicuous during the summer. Dwarf is caused by a nematode,[7] which under favorable conditions may reach and infect healthy plants. Runner plants from dwarf mother plants are usually

FIGURE 4.—Nematode gall of strawberry. (Photographed by Byars.)

dwarfed, and the disease is often introduced into new fields by planting infected plants. The only known methods of controlling the disease are to plant healthy plants and to remove at each hoeing any plants showing symptoms of dwarf.

[7] *Aphelenchoides fragariae* (Ritzema-Bos) Steiner.

VIRUS DISEASES

STRAWBERRY YELLOWS

Yellows is common on strawberries of the Marshall (Banner) variety in central California. The most conspicuous symptoms of the disease are (1) characteristic curling and cupping of the leaves, (2) yellowing of the leaves around the margin between the larger veins,

FIGURE 5.—Typical "dwarf" strawberry plant of the Klondike variety. (Photographed by Mook at Chadbourn, N.C., August 1928.)

and (3) dwarfing of the leaves and a general stunting of the growth of the entire plant. (Figs. 6 and 7.)

This disease is transmitted through the runners; that is, every runner plant from a diseased mother plant will be diseased. It is not transmitted through seed. The root system, however, appears healthy during the early stages of the disease. Under favorable con-

ditions for growth the plants sometimes appear to recover their vigor, but later show the symptoms of disease again. Complete recovery of the plant has not been noted.

FIGURE 6.—Young Marshall (Banner) strawberry plant showing typical yellows. (Photographed by Plakidas.)

Carefully controlled experiments, however, have proved that the disease is transmitted by a species of strawberry aphid (*Myzus fragaefolii* Cockerell), which fact, together with other characteristics, would indicate that it belongs to the class of virus diseases.

WITCHES'-BROOM

A disease of strawberries which seems to be of the virus type was found in western Oregon in 1925 and is reported only from this region. This disease, which is transmitted by the strawberry leaf aphid (*Myzus fragaefolii*), was named witches'-broom because one of the most characteristic symptoms of the disease is that the leaf petioles are more slender than normal ones and the leaves tend to bunch together. The runners of diseased plants become shortened so that runner plants stand close to the mother plants. The leaflets are lighter in color than in normal plants, and the margins arch downward. The "broom" character is exhibited more markedly by some varieties like Ettersburg No. 121 than by others. (Fig. 8.)

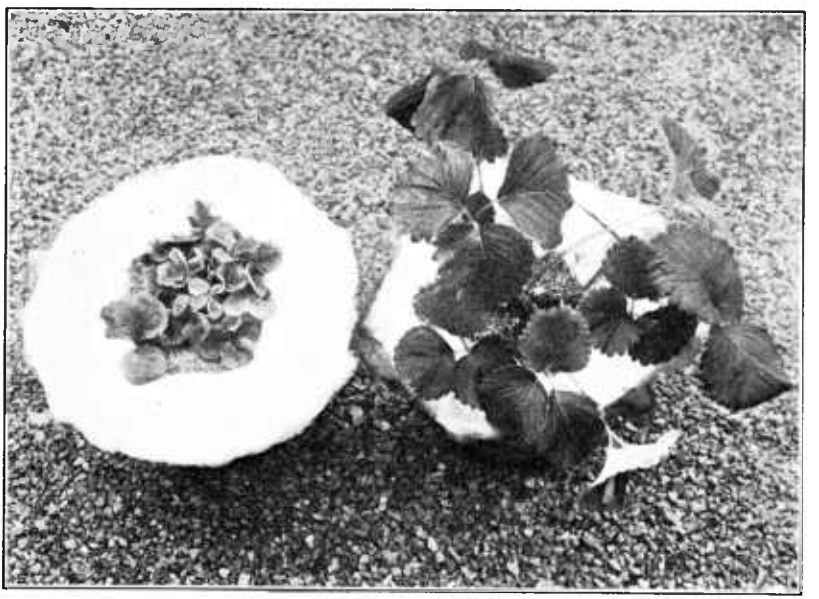

FIGURE 7.—Sister seedling plants of Marshall (Banner) variety of strawberry. Left, diseased with yellows; right, healthy. (Photographed by Plakidas.)

CONTROL OF VIRUS DISEASES

So far as present knowledge goes, control of virus diseases in strawberries must depend on the selection of healthy stock and on the elimination of diseased plants as they appear. Since strawberries are usually grown with a short rotation period and much handwork is usually involved in their culture, the destruction of diseased plants at frequent intervals should be easy.

DISEASES OF WHICH CAUSES ARE NOT DEFINITELY KNOWN

A LEAF DISEASE

A disease for which the names "June yellows" and "gold disease" have been suggested and which has thus far been found only in the northeastern part of the United States and in Canada, is undoubtedly different both from the yellows of the Pacific coast

and from the dwarf of the Southern States. Yellowing is its most striking symptom. The yellow color is so prominent that the diseased plants in a field may easily be seen from a distance. In extreme cases as much as 90 percent of the area of a leaf may be devoid of chlorophyll. The yellow color is nsually of a light hue, nearly albino. The affected leaves usually show a mosaiclike pattern of mottling or marbling, a fact which has led many of those who have seen the disease in the field to designate it as mosaic. The yellow leaves appear thinner than the healthy green ones. Curling, crinkling, cupping, or twisting of the leaflets is rare. The symptoms are most prominent during the cool weather of spring. The yellowing practically disappears in late summer. The disease seems to be of a

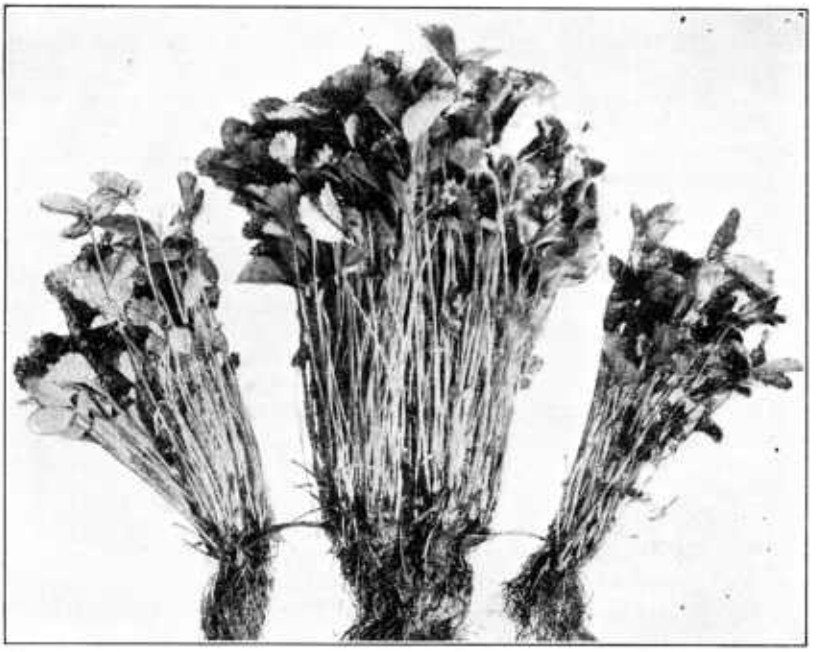

FIGURE 8.—Strawberry plant of the Ettersburg No. 121 variety, affected with witches'-broom, in which the runner plants have been pulled away from the mother plant to show the shortened internodes of the runners. (Photographed by Zeller.)

systemic nature; that is, all runner plants of a diseased mother plant are affected. The appearance of the disease and its behavior in the field have led to the suspicion that it might be of the virus type, yet transmission experiments carried out by experienced investigators have uniformly given negative results.

ROOT ROTS

Species of Rhizoctonia have been reported as associated with "black root" in Michigan, Tennessee, Washington, and other States. In Canada species of Fusarium and certain soil bacteria have been found associated with this type of disease, and a species of Diplodina was found apparently causing a disease of strawberry roots in England.

In Lanarkshire, Scotland, root diseases of strawberries have become very important. A species of Pythium has been isolated from diseased roots and proved by inoculation to be capable of infecting healthy plants. The work in that locality indicates, however, that while this and perhaps other fungi are no doubt an important factor in the injury, the condition of the soil and the general health of the plant are also of great importance.

During recent years strawberry growers have sustained heavy losses in various parts of the country from what appear to be root diseases. These diseases, which have usually been designated as "black root" or "red root," have been studied by investigators in various States, and several fungi have been isolated from the diseased roots. Thus far, however, all attempts to produce disease by inoculation with these fungi have failed. This failure by no means proves that these or other fungi are not responsible for the trouble, and certain fungi found on strawberry roots are now being actively studied. Meanwhile no information on which to base recommendations for control is available. For the present, growers must depend for control on selection of stock, careful culture, and frequent rotation, the last probably being the most important.

FRUIT ROTS

Fruit rots of strawberries, both on the plant and after the berries are picked, are caused by a variety of diseases, some of which are now known only in certain localities. In discussing each disease the region in which it is known to be serious will be indicated. This does not mean, of course, that the disease does not occur in other places; indeed, it is highly probable that many of these rots will be found in regions widely separated from those in which they are now known.

GRAY-MOLD ROT

The best-known and most widely distributed fruit rot of strawberries is that caused by gray mold (*Botrytis* sp.). This disease affects both green and ripe berries. The rot usually starts in the part of the berry that is next to the ground or that touches another berry or a leaf. It is first noticed as a light-brown, rather soft spot. The rot spreads in all directions through the berry and is not localized in any particular portion. After the berry is wholly rotten it soon begins to dry out and becomes firm and tough and of a uniform color throughout. At this stage it is almost entirely covered by a firm gray powder or dusty-appearing fungous growth, the well-known gray mold. This disease is most common in the cooler strawberry-growing regions. It is often very destructive in Maryland, Delaware, New York, and New England, where it is not unusual for it to cause 10 percent or more of the crop to be lost. The disease is especially favored by moisture and may become destructive in any of the large strawberry-growing sections during continued wet weather.

The growth of gray mold can not be entirely prevented by refrigeration. Under the conditions in many refrigerator cars, strawberries affected with this disease often become covered with an abundant growth of soft, fluffy, gray mold, which is very conspicuous and seriously hurts the sale of the entire load. Consequently, it is

important that berries affected with gray mold be carefully culled out during picking and packing.

The injury caused by gray mold is not confined to the fruit. The blossoms are frequently blighted by this disease, and under favorable conditions leaf and flower stalks may be infected and the whole plant thus seriously injured.

TAN ROT

The so-called tan rot [8] is important, especially during rainy seasons, in Louisiana, Florida, Arkansas, Virginia, Maryland, and North Carolina. It may attack either green or ripe berries, forming slightly sunken tan-colored areas, which usually develop on the side of the berry. The rot extends into the pulp so that the rotten portion forms a cone with its base at the surface of the berry. The outer layer of this diseased area becomes soft and as the core of the rotten portion is held together by the rot fungus it is easily removed intact with the point of a knife or pencil. This characteristic serves to identify this trouble readily.

LEATHER ROT

Leather rot,[9] which has been found in Alabama, Louisiana, Mississippi, Arkansas, Missouri, Tennessee, Kentucky, Illinois, Maryland, and Virginia, is readily distinguished from other fruit rots by the bitter taste of berries that are even slightly rotted. This disease may affect either ripe or green berries in any stage of development. When ripe berries are affected, all parts become dark brown over the affected areas or brown at the edges, shading off into the natural green. Partly colored berries show the same light-brown color at the center, but the spot shades off into purple and finally to the red of the berries. If a berry affected with this disease is cut across, a marked browning of the vascular strands is readily noted. This is usually accompanied by a less marked browning of the other tissues. At no time is there any clear line separating the diseased and healthy flesh, nor can the diseased portion be easily removed, as in the case of tan rot. The disease is most noticeable after rainy periods, especially if the weather is warm. Leather rot has proved very serious in White County, Ark., and in Tennessee. During some years more than one-fourth of the crop in these localities has been lost.

HARD ROT

Hard rot [10] is known to be serious in the strawberry fields of central Florida, and has been found in North Carolina, Arkansas, and Tennessee. As the rot is caused by a soil fungus, it almost always occurs on the side of the berry that comes in contact with the soil, and a small quantity of soil will usually be found clinging to the decayed spot.

The affected berries are generally one-sided and show a hard brown rot separated from the sound portion of the berry by a distinct line. The portion of the berry not actually penetrated by the rot fungus remains unchanged both in appearance and in taste.

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[8] Caused by *Pezizella lythri* (Desm.) Shear and Dodge.
[9] Caused by *Phytophthora cactorum* Leb. and Cohn.
[10] Caused by *Rhizoctonia* sp.

FRUIT ROTS IN TRANSIT AND ON THE MARKET

The various rots just described are all found to a greater or less extent on berries in the field. A very large proportion of the rotten berries in most cull piles are infected with one or more of the fungi just mentioned. Their relative abundance varies in different parts of the country and with weather conditions. In general, as every strawberry grower knows, these field rots are more abundant during or immediately after a period of wet weather. It is during such rainy periods that the greatest number of rotten berries must be thrown out as culls when the berries are sorted in the packing shed.

Serious as is the loss from field rot, it is not so costly as the rots that occur in transit and on the market. Field rot means a reduction in the size of the crop and some added cost in the packing shed. Rot that develops in transit, however, means that the labor of growing that much of the crop has been wasted, as well as the cost of picking, packing, and hauling to the railroad. To this waste must be added the expense of loading in the cars and the cost of freight or express and of refrigeration. Often more important than any of these is the disastrous effect on the market of the presence of moldy or leaking berries in the crates offered for sale.

All of the fruit rots described are known to develop to some extent in transit. Gray mold, because of its wide distribution and its ability to grow somewhat at the temperatures usually obtained in refrigerator cars, is the most important in transit of any of the brown rots.

LEAK

More important than any of the brown rots, indeed more important in transit and on the market than all of them put together, is the rot almost universally known as "leak."

As its common name indicates, leak [11] is characterized by the collapse of the berry and the loss of much juice. Even one or two leaking berries will stain a box and make it unattractive, and it is not uncommon for the juice to drip from boxes and crates of badly infected fruits. Spores of the black mold are almost always abundant in the air of packing sheds, stores, and houses. Once inside the fruit, black mold will destroy a strawberry much more quickly than any other fungus now known. Fortunately, however, this fungus usually enters the berry only through wounds and grows very slowly at temperatures below 50° F. Control measures, then, must be directed toward careful handling and the maintenance of low temperatures.

Leak is, of course, most important in strawberries grown in the Southeastern States and shipped long distances to market. Its severity in this area is shown by careful compilations of information from the certificates of the food-products inspection service of the Bureau of Agricultural Economics, United States Department of Agriculture. These summaries show that the loss caused by leak was practically one-fourth greater than that caused by all other rots for the period 1919–25, and greater than any other rot for the period 1926–30. The exact figures in the earlier period were 4.9 percent

[11] Caused by the common black mold, *Rhizopus nigricans* Ehrb.

loss due to leak in cars examined and 3.9 percent loss due to all other rots. For 1926–30 the losses were somewhat lower. This same report also shows the difference between the amount of rot in wet and dry seasons. Figure 9 gives a comparison of the rot in Arkansas, Tennessee, and Louisiana during two wet years (1922 and 1923) and two dry years (1924 and 1925).

CONTROL OF FRUIT ROTS

Successful methods of controlling fruit rots in grapes and most tree fruits, namely, spraying or dusting, have not proved practicable with strawberries. While experiments in Arkansas did indicate that the amount of field and storage rot could be reduced in certain years by spraying or dusting, the rot proved not to be of sufficiently regular occurrence to justify the expense of treatment. There is no indication that any practicable application of spray or dust will reduce the loss from leak, which, as already noted, is the most important of all strawberry rots.

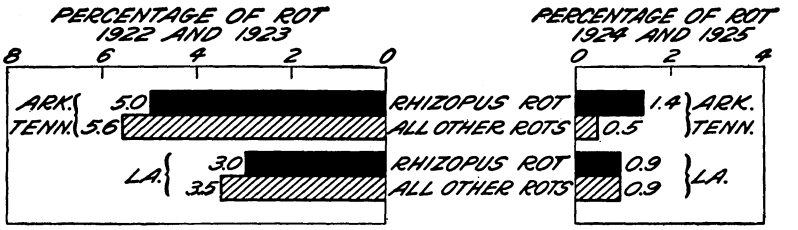

FIGURE 9.—Percentage of Rhizopus rot and of all other rots in carload shipments of strawberries from Arkansas, Tennessee, and Louisiana for two wet years (1922 and 1923) and two dry years (1924 and 1925).

MULCHING

Mulching, if carefully done, reduces the loss from rots in two ways: (1) It reduces the infection from certain fungi which apparently gain entrance from the soil, especially leather rot and hard rot, and (2) by keeping the berries free from soil it reduces the chance of bruising and thus lessens the opportunity for infection by black mold.

CAREFUL HANDLING

As is true of many other fruits, careful handling is one of the best means of reducing the loss from rot in strawberries. Careful handling is important at every stage—in picking, in sorting, in packing, and in loading the crates on trucks or into cars. This requires careful supervision of all employees and careful training of inexperienced pickers.

KEEPING THE BERRIES COOL

All rot fungi are favored by high temperatures. Although gray mold can not be entirely checked by any degree of refrigeration which can safely be secured at present, even this rot grows much more slowly at low temperatures. It is therefore of first importance that strawberries be kept as cool as possible from the time they are picked until they are eaten. A useful method of accomplishing this and one that has proved most advantageous in practice is to

pick as large a part of the crop as possible early in the day, while the fruit is still cool. Not only does this result in the berries reaching the car cooler and thus requiring less ice to remove the "field heat," but the berries are actually less easily bruised if picked while cool.

Careful tests of the pressure required to puncture strawberries and other small fruits showed that it was greater for cool fruit than for warm fruit. This was equally true whether the fruit was wet or dry.

BEST PRACTICE WHEN STRAWBERRIES ARE WASHED BEFORE PACKING

In some sections, notably central Florida, cultural and trade practices make it necessary to wash the berries before they are packed. When this is done the berries should not be dried after washing but merely allowed to drain for a short time and packed while still moist, and kept in the shade until they are delivered to the loading platform. It is important that the water in which the berries are washed should be changed frequently. Dirty water not only contains sand, which makes it much easier to injure the berries in handling, but it contains spores of different mold fungi, particularly Rhizopus, which greatly increase the loss from decay.

REFRIGERATION IN TRANSIT

Careful handling to prevent bruising, and quick cooling after harvesting, are both important, but, of course, do not assure that the fruit will reach destination without loss. The fruit must be properly refrigerated in transit.

It is desirable to keep the fruit temperatures in transit below 45° F.; 40° is still better. These temperatures, however, are rather difficult to maintain unless salt is used in the bunkers with the ice. For this purpose, the quantity of salt added at the initial icing should be from 1½ to 2 percent of the ice by weight. At the first reicing salt may be again added in the same proportion, that is, between 1½ and 2 percent of the additional ice.

A great aid in maintaining low fruit temperatures in transit is to precool the fruit after it has been loaded in the car and before the shipment moves to market. This may be done in various ways, one of the simplest of which is the use of a precooling device developed by the United States Department of Agriculture.[12]

REDUCTION OF LOSSES FROM FRUIT ROTS

The methods suggested for the control of fruit rots—mulching, careful handling, care in keeping the berries cool before they are loaded, and adequate refrigeration in transit—are certainly less spectacular than a spray program or some special treatment, yet they are of proved value.

Recent summaries of losses in transit, compiled from the reports of the food-products inspection service of the Bureau of Agricultural Economics, make possible a rough comparison of the losses due to decay in transit from certain Southern States having long hauls to market. These reports are based solely on market inspections

[12] Copies of a mimeographed circular describing this device and giving instructions for its use are available for distribution on request.

by unprejudiced observers and, therefore, furnish a type of information not obtainable from the usual sources of plant-disease reports or crop-loss estimates. The certificates studied included shipments from Alabama, Arkansas, Delaware, Florida, Kentucky, Louisiana, Maryland, Missouri, North Carolina, Tennessee, and Virginia. These States produced in 1930 over 113,000 acres of strawberries, which represented almost two-thirds of the commercial strawberry acreage of the country.

Using as a measure of loss what D. H. Rose has called a "disease index," namely, the sum of the percentages of all the diseases noted, and comparing the 4-year period 1923–26 with the 4-year period 1927–30, there was shown a reduction of losses in transit from 5.7 percent during the earlier period to 3.8 percent during the latter. If these percentages look small, it should be remembered that the annual commercial strawberry crop of the United States ranges from 200,000,000 to 300,000,000 quarts.

Among the factors that may account for this difference, improved handling methods and improved refrigeration seem to be the most probable. There have been few changes in varieties or in cultural methods, but much educational work has been done which has tended to improve handling methods, and there have been mechanical improvements in refrigeration and equipment. Perhaps the greatest single improvement is the general shortening of the time between field and car by improved roads and the general use of trucks for transportation.

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